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A Microchannel Plate Streak Camera

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A Microchannel Plate Streak Camera*

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Abstract

The development of a streak camera using microchannel plate electron multiplier as the cathode is presented. Potential applications to γ-rays, low energy x-rays and charged particles are described. Preliminary test shows that 150 ps resolution can be obtained.

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Introduction

We report the development of a streak camera (SC) using microchannel plate electron multiplier (MCP) as the cathode. Figure 1 illustrates the configuration of such a device. Except for the cathode, it is essentially the same as the conventional x-ray streak camera. We describe some of the potential applications and present the result of a preliminary test.

Potential Applications

1. As a Gamma-ray Streak Camera

Since the MCP has much higher detection efficiency for γ-rays than the conventional photocathode, one of the most interesting applications of the MCPSC is for γ-ray or high-energy x-ray detection. Figure 2 is a compilation of the MCP detection efficiencies for 0.1 - 1000 KeV photons[1,2,3]. It is seen that the MCP retains its >1% efficiency for γ-like photon energies. Photocathodes, on the other hand, have rather small quantum efficiencies for MeV photons. Figure 3 shows the back-surface secondary electron quantum yields for a 230 Å Au transmission photocathode[4,5]. Since the quantum efficiency for MeV photons is $\sim$ 0.05%, the MCPSC is 20M times more sensitive than the conventional x-ray streak camera, where M is the minimum number of secondary electrons needed to register a trace on the film.

2. For Low-Energy X-ray Application

Low energy x-rays are strongly attenuated in the photocathode. The situation is particularly serious in high-resolution spectroscopy where x-rays are incident at large angle on the photocathode that is placed on the Rowland circle. Since the MCP transmits secondary electrons from the front surface to the rear, it is ideal for detecting low energy x-rays incident at large angle to the normal to the cathode.

3. For Charged Particle Application

Figure 4 shows the detection efficiency of the MCP for various types of radiation[6]. The MCP is sensitive to charged particles as well as to photons. The MCPSC may therefore find useful applications for charged particles.

Experiment

We have obtained preliminary data using UV and soft x-rays at our Monojoule laser facility. Indeed, the MSPSC is so sensitive that we turned off the laser amplifiers and only the oscillator was used, yielding 100 ps laser pulses of about 50 μJ. The UV and x-rays generated from a Ta disk target were detected with the MCPSC. Figures 5 (a) and (b) show typical streak traces and their exposures respectively. An etalon was used in the laser beam to provide multiple pulses at 800 ps intervals. The FWHM of the weakest trace is 150 ps. Since the exact duration of the UV and x-ray pulse is not known, the resolution of the MCPSC is estimated to be less than 150 ps. The major part of this time resolution is attributed to the large energy spread of the secondary electrons from the MCP cathode. We intend to improve the resolution by selecting a narrow energy band of electrons with an electrostatic analyzer.

References

1. W. Parkes, R. Gott, and K. A. Pounds, IEEE Trans. Nucl. Sci. NS-17, 360 (1970).
2. K. W. Dolan and J. Chang, SPIE 106, 178 (1977).
3. J. Adams and I. C. P. Millar, Acta Electronica, 14, 237 (1971).
4. B. L. Henke, J. P. Knauer, and K. Premaratne, J. Appl. Phys. 52, 1509 (1981).
5. V. W. Slivinsky and G. R. Leipelt, University of California Lawrence Livermore National Laboratory Report UOPE 70-71, 1970 (unpublished).
6. D. J. Ruggieri, IEEE Trans, Nucl. Sci. NS-19, No. 3, 84 (1972).

Figure Captions

1. A microchannel plate streak camera and the experimental setup.
2. Compilation of microchannel plate efficiencies from various authors: Parkes (Ref. 1), Dolan (Ref. 2) and Adams (Ref. 3).
3. Back-surface secondary electron quantum yield for a 230-Å Au transmission photocathode.
4. Detection efficiencies of microchannel plate for various types of radiation.
5. (a) Typical streak traces and (b) their exposures obtained for UV and x-rays generated at our 1.06 μm, 100 ps Monojoule laser facility operated at 50 μJ.

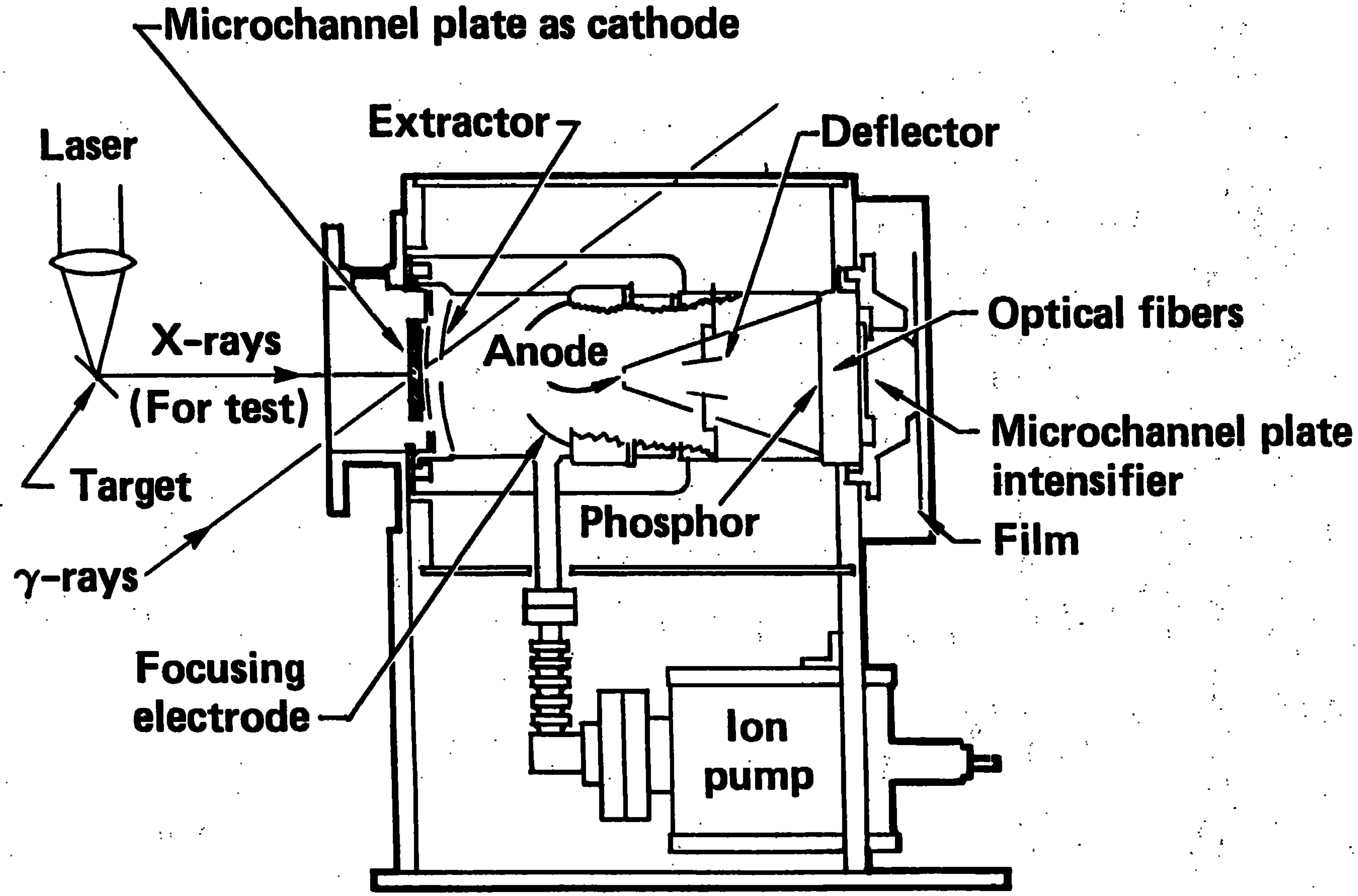

Microchannel plate as cathode
Laser
Extractor
Deflector
X-rays
(For test)
Anode
Optical fibers
Target
Microchannel plate
intensifier
Phosphor
Film
γ-rays
Focusing
electrode
Ion
pump

Fig. 1

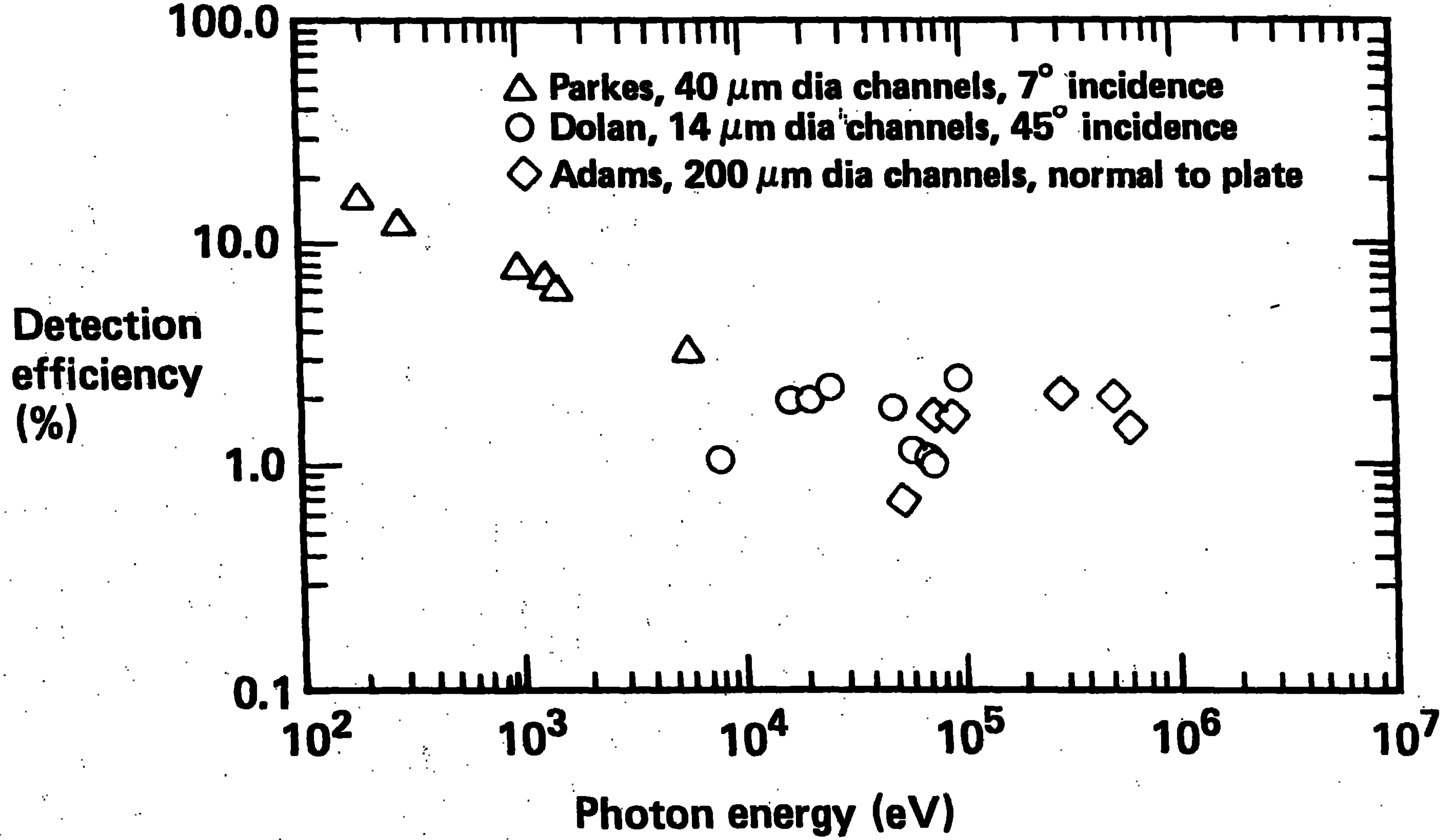
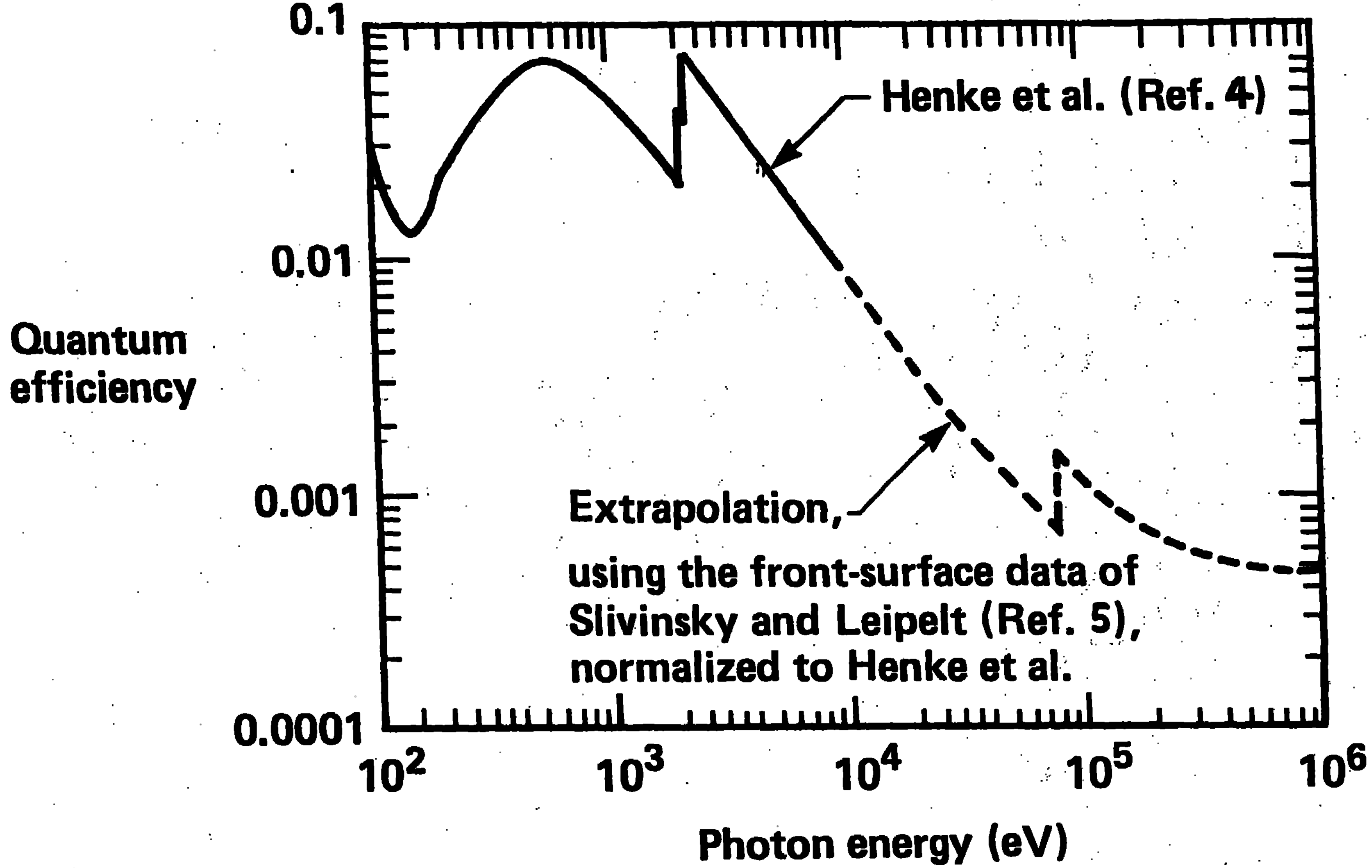
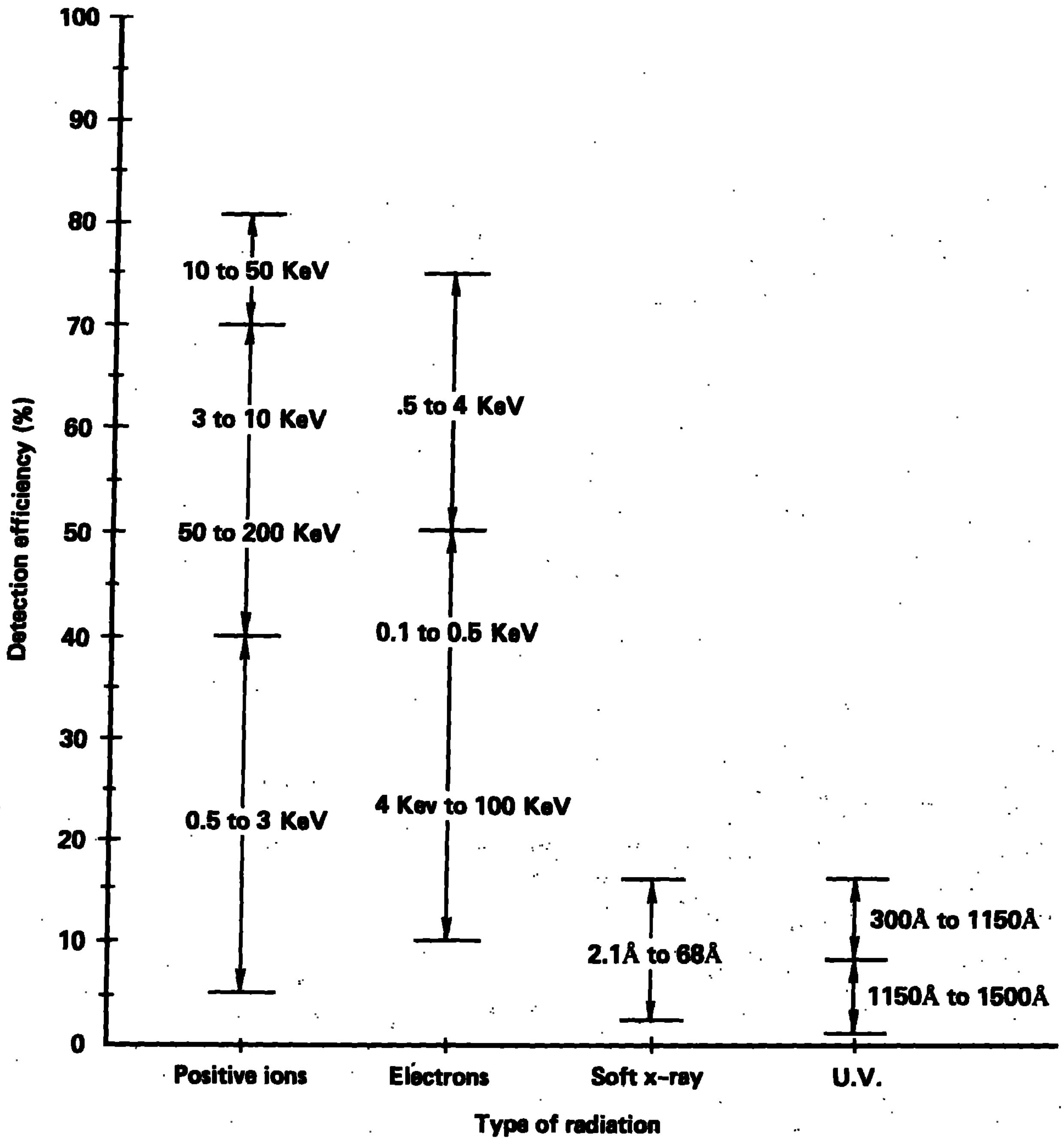

100.0
10.0
1.0
0.1
Detection efficiency (%)
△ Parkes, 40 µm dia channels, 7° incidence
○ Dolan, 14 µm dia channels, 45° incidence
◇ Adams, 200 µm dia channels, normal to plate
10^2
10^3
10^4
10^5
10^6
10^7
Photon energy (eV)

Fig. 2



0.1
0.01
0.001
0.0001
Quantum
efficiency
Henke et al. (Ref. 4)
Extrapolation,
using the front-surface data of
Slivinsky and Leipelt (Ref. 5),
normalized to Henke et al.
10^2
10^3
10^4
10^5
10^6
Photon energy (eV)

Fig. 3



Detection efficiency (%)
100
90
80
70
60
50
40
30
20
10
0
10 to 50 KeV
3 to 10 KeV
50 to 200 KeV
0.5 to 3 KeV
.5 to 4 KeV
0.1 to 0.5 KeV
4 Kev to 100 KeV
2.1Å to 68Å
300Å to 1150Å
1150Å to 1500Å
Positive ions
Electrons
Soft x-ray
U.V.
Type of radiation

Fig. 4

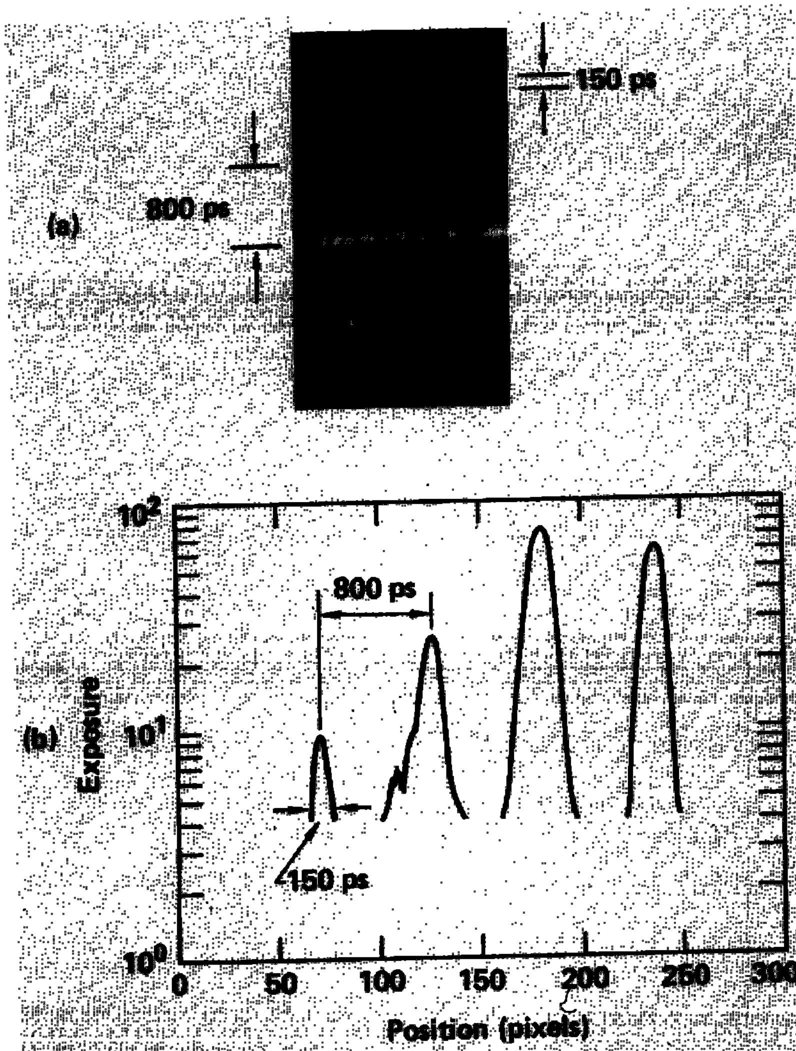

150 ps
(a)
800 ps
(b)
800 ps
150 ps
Exposure
10^2
10^1
10^0
0
50
100
150
200
250
300
Position (pixels)

Fig. 5